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COMPOSITION AND SOURCE OF THE FLORA OF THE CINCINNATI REGION

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I. INTRODUCTION

The Cincinnati Region lies in the western half of the Deciduous Forest Area (27). The underlying formation is Upper Ordovician limestone and shale, overlaid, except on the steeper slopes, with glacial drift of the Illinoian and Wisconsin periods; the former is rather level, compact and impervious, the latter gently sloping and contains many pebbles in a clayey matrix (7, 1917). Ecologically, the flora of the region is most closely related to that of the east and southeast. However, certain of its plant communities bear distinct evidence of western relationship. The explanation of all of these relationships is to be sought in the post-glacial migrations of the elements of our flora.

The most important centers of dispersal for post-glacial migrations in eastern United States have been the Southeastern Center and the Boreal Center (1). Migrations from these centers readily account for the larger part of the plant population of the Cincinnati Region. However, a number of western plants, for the most part grouped in distinct communities, here reach or approach the eastern limits of their geographic range. From their present range it is impossible to consider that they have been derived from either the Southeastern or the Boreal Center.

In the western half of the continent are two centers of dispersal which have affected the composition of our flora. One is a center of desert vegetation, situated on the arid plateau region of Mexico and southwestern United States; the other, a center of prairie vegetation, lies farther north in the grassland area (1, 19). (See map, fig. 1.)

II. MIGRATION PATHWAYS

The paths of migration by which the present elements of our flora have arrived have now to be sought. Of the three primary outlets of dispersal from the Southeastern Center (1), two are possible and probable pathways: (1) the valley of the Mississippi river and its tributaries; (2) the Appalachian mountains and adjacent plateaus.

Boreal elements may have become a part of the flora of the region, (1) by migration from the North along the pathway of the Appalachian mountains and adjacent plateaus; (2) by lagging behind during early post-glacial migrations, and continuing to exist in more or less modified condition, as relicts of an earlier flora.

The paths of invasion for the western elements of the flora are marked by broken lines of related plant communities which occupy a series of continuous or almost continuous, similar, but gradually changing habitats, with no great geographic barriers between them. Three possible lines suggest themselves: (1) the eastern extension of the prairie across Indiana into western Ohio; (2) the outwash gravels of the several glacial stages along the north-south streams south of the Great Lakes may form connecting bands between the Cincinnati Region and the sandy shores and dunes of the more western of the Great Lakes, to be known as the Great Lakes-stream terrace pathway; (3) the artificial eastward extension of western xerophytic habitats by the construction of railway roadbeds of gravel.

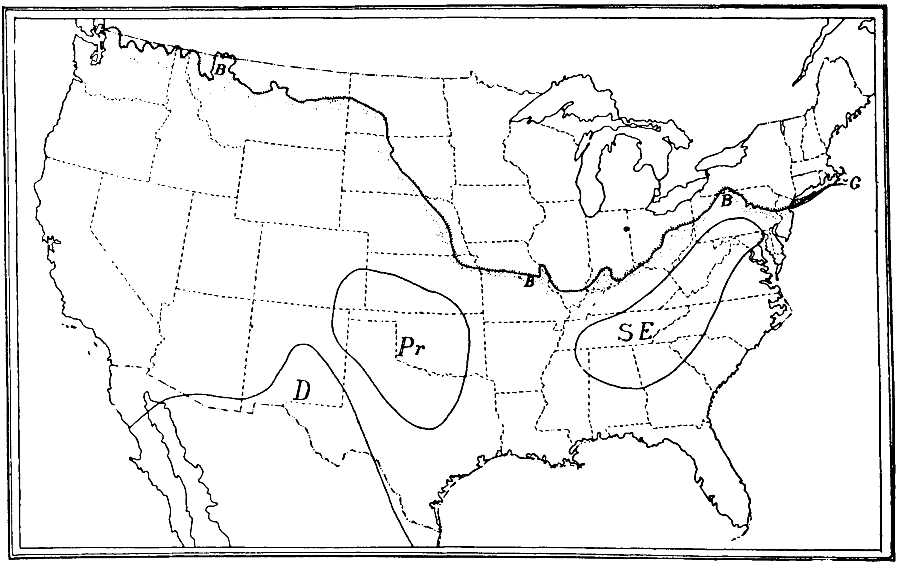

Fig. 1. Map showing southern margin of the ice sheet (*GG*) and probable area occupied by boreal plants (*BBB*) at the time of maximum glacial extent; southeastern centre of dispersal (*SE*); prairie centre (*Pr*); desert centre (*D*). (Location of centres according to Harshberger, 19.)

Let us now consider these pathways of invasion as physiographic and ecological units, in order to compare them with the various types of habitats and plant associations of the Cincinnati Region.

A. Paths of Migration from the Southeastern Center

1. Valleys of the Mississippi River and its Tributaries.—The alluvial plains of the Mississippi and Ohio rivers form a continuous path from the south, in which soil and topographic conditions are similar throughout (except for local variations), and along which climate and rainfall change but gradually, though quite different at the two extremes. Ecologically, the area is a continuous though gradually changing flood plain formation, from which, one by one, various species drop out, reaching their northern limit. Thus in the western and southern part of the Cincinnati region, on the high alluvial plains of the Miami and the Licking rivers, pecan, *Carya illinoensis,*[1]

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[1] Names used are those of Gray's New Manual of Botany, seventh edition.

reaches its northeastern limit. The Mississippi valley does not serve as a migratory pathway for the western elements of our flora, because western plants, adapted to xerophytic conditions of an arid climate, can not successfully compete with flood plain vegetation. It may, however, serve as an inlet for plants entering our territory from regions still more southerly than the Southeastern Center.

2. APPALACHIAN MOUNTAINS AND ADJACENT PLATEAUS.—These together constitute a major physiographic division, the Appalachian Highlands (13). This area is continuous for great distances as a northeast-southwest band, and thus may serve alike as a northward or southward path of migration. Ecologically, most of the southern half of the Appalachian Highlands is included in the Deciduous Forest area (27), and presents a great variety of plant associations resultant upon the great diversity of topographic form. The northern half is occupied by the Northern Mesophytic Evergreen and the Northeastern Evergreen-Deciduous Transition forests (27). The physiographic boundary is not sharply reflected in the plant formations, many continuing with little change across the Interior Low Plateaus. It is the absence, west of the edge of the plateau region, of the majority of conifers, which produces the seemingly great difference in vegetation. The Appalachian Highlands approach at one point within about fifty miles of the Cincinnati Region, a distance not too great to be readily bridged in migration, especially as no geographic barrier intervenes.

B. PATHS OF MIGRATION FROM THE BOREAL CENTER

1. APPALACHIAN MOUNTAINS AND ADJACENT PLATEAUS.—There is no evidence that the Appalachian Highlands have played a part in determining the composition of our flora through southward migration of boreal forms.

2. BOREAL FORMS LAGGING BEHIND DURING EARLY POST-GLACIAL MIGRATIONS.—Boreal forms lagging behind during early post-glacial migrations and continuing to exist are necessarily those with the greatest degree of adaptability to changing conditions of environment. At the time of maximum glacial advance of the last (Wisconsin) stage, part of the Cincinnati Region was covered by the ice sheet (fig. 1). Thus boreal plant communities at that time occupied or were south of our area, and commenced their northward migration across the area with the retreat of the ice front (29). No decidedly boreal species are found in the Cincinnati Region, though a few plants which may be considered as belonging to the Canadian element are characteristic in some communities. Certain plant associations, namely, the earlier stages of the meadow-forest hydrarch succession of the uplands (6) resemble very closely in physiognomy related associations of the far north. In the earliest stages of this upland succession, lichens, especially Cladonias, *C. pyxidata*, *C. verticillata*, *C. mitrula*, *C. cristatella*, and mosses,

especially Catharinea, are the dominant vegetation. A lichen and moss "tundra" is formed which is slowly invaded by grasses and herbs, accompanied by a scattering of shrubby willows.

C. Paths of Migration from the Western Centers

Plants from the Southwestern or Desert Center and from the Prairie Center appear to have used the entering pathways of migration in common, at least to some extent. However, the eastward extension of prairie across Indiana into western Ohio has functioned most prominently as a means of entrance of prairie plants, while the Great Lakes-stream terrace pathway and the railway roadbeds, especially the latter, have been more important modes of entrance for more xerophytic plants.

1. Eastern Extension of Prairie Across Indiana into Western Ohio.—The boundary between the Deciduous Forest area and the Grassland–Deciduous-Forest Transition is ill-defined. Grassland and forest exist side by side in the transition area in Illinois, but on different soil types, the character of the soil evidently being the factor deciding the limits of tree growth (**15**). Eastward, throughout the Till Plains of the Central Lowland province, and within the Deciduous Forest area, local edaphic prairies or prairie meadows exist. Some of these are very small, only an acre or two in extent; others, as those in Montgomery County north of Dayton, Ohio, and Big Spring Prairie, in Hancock, Seneca and Wyandot Counties, are much larger. Though the line is broken by intervening areas of forest, and the existing prairie patches much reduced in size by encroaching cultivation, the continuity of the plant formation from the prairies and plains to the Cincinnati Region is evident.

2. The Great Lakes–Stream Terrace Pathway.—This is probably the least continuous of the natural invasion channels, and at most is but an indirect path of migration from the west. It doubtless serves as a means of east-west communication along the lake shores. River terraces of sand and gravel present habitats somewhat similar to high sandy shores, and offer a possible though broken course for southward migration. The presence of *Rhus canadensis* on the gravel terraces of the Cincinnati Region and in the dune region of the Lakes suggests this connection. Sand cherry, *Prunus pumila,* in sandy soil of southern Ohio, and on the open dunes of the Great Lakes, further suggests this pathway from the Lakes, although in this instance intervening stations are not known.

3. The Artificial Eastward Extension of Western Xerophytic Habitats by the Construction of Railway Roadbeds of Gravel.—In relatively recent years, and since natural migration pathways are becoming more and more broken by man's intervention, artificially constructed pathways are gaining in importance as means of plant migration. Railway road-

beds constructed of gravel or crushed stone, even across a relatively humid region, are xerophytic. The pathway, even though extremely narrow and precarious, is serving today in the spread of plant species. Every plant collector knows that a systematic search along the railroads entering a region is apt to yield new records. Some of these are transients, others soon become established as a part of the flora of the invaded region. The bee-flower, *Cleome serrulata,* abundant throughout the prairie and plains regions, is recognized in manuals (17) as a traveler along the railroads. In the past ten years seventeen species, or about fifteen percent of the additions to the flora of the Cincinnati Region in that time, have been recorded from railroad tracks. Six of these are from the West, the remainder are European. Over half of the seventeen, or eleven percent of the total additional number, seem to be established. Only two species (less than two percent of the total) are present in such small quantities as to make their establishment doubtful. This would appear to be conclusive evidence of the efficiency of railway roadbeds as a pathway for plant migration and ecesis. And as this pathway has served in the past ten years, so must it have served in all the previous years since the building of railroads to the West.

One other mode of migration must be considered. That is intentional or unintentional carrying of propagules by man. Packing materials, cattle bedding, and grass seed undoubtedly serve as carriers. This mode of migration is closely related to the last, for it is probable that at least a part of the migrants on railroad tracks are carried on cars. This difference exists, however, that propagules may be introduced by man in such numbers locally as to make ecesis less precarious if edaphic factors are not adverse. For this reason, species which are apparently abundant locally one year may almost totally disappear in a few years where conditions are not suitable.

Migration is only the first step in ecesis. The various migration pathways entering the Cincinnati Region are distinct in present ecological characteristics and appear to have been so in the past. Entering forms must find habitats similar ecologically to these pathways, and hence to the region from which they are traveling, in order that invasion may lead to successful establishment.

III. COMPOSITION AND PROBABLE SOURCE OF FLORA OF THE PLANT COMMUNITIES OF THE CINCINNATI REGION

A. Typical Plant Communities

Without regard to successional relationships, the plant communities of the Cincinnati Region may be grouped according to physiognomy, into forest and herbaceous communities, each subdivided according to origin and xeromorphy (see table of contents).

Most of these vegetational divisions have been described elsewhere (6).

Some are associations of the primary successions, entirely natural, and independent of man's interference; others (prairie patches) appear in primary and in secondary successions, either naturally or induced by a minimum of interference; still others, as the waste lands and "deserts," appear only after natural conditions have been greatly disturbed by man.

B. Composition and Source of Flora

In the study of the composition of the flora of the various plant communities only characteristic species are considered; that is, those species which are dominant, persistent in appearance, or completely restricted to their respective communities. The geographic range of the species concerned is taken from various manuals and state flora or lists (Britton and Brown, **8**; Coulter and Nelson, **9**; Gray, **17**; Small, **28**; Schaffner, **25**; Garman, **16**; Bergman, **3**; Petersen, **24**; Coulter, **10**; Aiken, **2**; Dean, **11**).

Attention is paid to distribution of our local plants within the State of Ohio (**25, 26**) as indicating possible relationships northward or eastward. The absence of certain plants of western distribution from other parts of the State indicates that a portion of our flora is of western origin, and that the Cincinnati Region lies at the eastern border of a transition belt. The State is divided into an eastern and a western half by a prominent physiographic boundary: the eastern half lies in the Appalachian Plateaus province; the western in the Central Lowland province (**13**). The eastern half is a maturely dissected area with strong relief, which originally was entirely forested. The western half is a low plateau, crossed by several large streams for the most part in shallow valleys. The original forest of the plateau was frequently interrupted by prairie patches. The forest itself, or what remains of it, is dominantly oak.

The several plant communities are considered separately.

1. *Forest Communities*

a. Upland Forests.—In upland forests are included the various forest associations preceding the pre-erosion climax (**6**). The most characteristic species of these forests are:

Quercus palustris, pin oak
Quercus bicolor, swamp white oak
Acer rubrum, red maple
Liquidambar styraciflua, sweet gum
Nyssa sylvatica, sour gum
Carya ovata, shell-bark hickory
Carya alba, white-heart hickory

All of these, except sweet gum, are generally distributed in Ohio; this species is confined, with the exception of local areas in Greene County, to the counties bordering the Ohio river. It is the only one of the characteristic upland forest species having a marked southerly range, the only one distinctly of the Carolinian zone (**23**).

A ground cover in these forests is in many cases almost totally absent; many species that do appear are scattered individuals of plants properly belonging to the herbaceous community of the forest opening. In other instances the ground layer is made up of a dense growth of hydro-mesophytic shrubs and herbs of such general distribution on moist soil that they can scarcely be considered as characteristic of upland forests. Excluding the above plants, there remains a small group of shrubs and herbs which belongs distinctively to the upland forest. They are:

Ilex verticillata, winterberry
Pyrus melanocarpa, chokeberry
Rosa carolina, wild rose
Polygonum sagittatum, arrow-leaved tear-thumb
Impatiens biflora, spotted touch-me-not
Viola cucullata, blue violet
Carex crinita, C. intumescens, C. lupulina, C. squarrosa, C. stipata, C. tribuloides, C. triceps hirsuta, C. typhinoides

This forest community finds its counterpart in similar communities variously scattered through the eastern half of the country. Its relationships are mostly eastern and southern; its center of dispersal is the southeastern. It represents, in modified form, the earliest post-glacial forest, the first invasion of forest plants into the arctic tundra of the glaciated area. Among its trees, red maple is considered one of the pioneers in forest advance (19). Its shrubs and herbs and abundant sedges represent the Canadian and Alleghanian elements of our flora and emphasize the boreal relationship of the community (19, 20, 23, 18, 4). They are, in a measure, a relict colony, surrounded and largely crowded out by plants of later invasions.

b. Flood Plain Forests.—The characteristic species of all associations of the flood plain forest are here grouped together. They are:

Salix nigra, black willow
Salix alba vitellina, yellow willow
Populus deltoides, cotton-wood
Ulmus americana, white elm
Platanus occidentalis, sycamore
Acer Negundo, box elder
Acer saccharinum, soft or silver maple
Carya cordiformis, bitternut hickory
Carya illinoensis, pecan

All of these except pecan are generally distributed in Ohio.

Pecan, *Carya illinoensis,* is present in the Cincinnati Region, but not elsewhere in Ohio, and here is represented by only a few trees. It is the one species of the group with very marked southerly range, the one which most clearly points to the Mississippi valley as the migratory pathway of some elements of our flora. Along the Ohio valley in Kentucky the recorded range (16) brings pecan into Gallatin County within less than fifty miles of stations in Kenton County, Kentucky, within our region. With but one break below this, the connection with the south is continuous. Historical references would indicate that the range of pecan has been somewhat curtailed, and that the western portion of the Cincinnati Region is to be recognized definitely as the northeastern limit of the tree. For Daniel Drake has said (12) pecan is "common in the Indiana Territory as far north as the latitude of Cincinnati, but is not found east of the Great Miami." While by no means "common," pecan is now growing in the Miami valley.

Bald cypress, *Taxodium distichum,* approaches so close to the arbitrary boundaries of the Cincinnati Region[2] as to be worthy of mention here as further demonstrating the southern relationship of the flood plain forest formation of the vicinity.

Of the large number of herbaceous plants which may enter the flood plain forest, but which more generally belong to shores or the more mesophytic forests, a few are characteristic. They are:

Laportea canadensis, wood nettle
Scutellaria lateriflora, skull cap
Ambrosia trifida, giant ragweed
Rudbeckia laciniata, tall cone-flower
Amphicarpa monoica, hog peanut
Sicyos angulata, one-seeded bur cucumber
Acalypha ostryaefolia, hornbeam three-seeded mercury

All but the last of these are generally distributed in Ohio. Their general geographic range, while in all cases widespread, is decidedly southern, all of these species extending northward from the Gulf coast over our region. The last named, *Acalypha ostryaefolia,* thus far has been recorded from only three Ohio river counties, and appears to be a rather recent invader in the Cincinnati Region. It is a southern species, belonging to a genus with southern and tropical deployment.

The range and distribution of all species of the flood plain forest formation points conclusively to a southern origin. Most of the species have spread from the Southeastern Center. A few appear to have come from more southern regions.

c. The Climax Mesophytic Forest.—The most characteristic trees of the mixed mesophytic forest, the climax of the Cincinnati Region, are:

Fagus ferruginea, beech
Acer saccharum, sugar maple
Liriodendron tulipifera, tulip tree
Fraxinus americana, white ash
Cornus florida, dogwood
Morus rubra, mulberry
Gymnocladus dioica, Kentucky coffee tree
Aesculus octandra, sweet buckeye
Ulmus racemosa, rock elm

As a ground cover in this forest are a large number of herbs and a few shrubs, among which the following are most uniformly present and most decidedly limited to this forest:

Phegopteris hexagonoptera, beech fern
Asplenium angustifolium, spleenwort
Asplenium acrostichoides, silvery spleenwort
Erythronium americanum, yellow adder's tongue
Orchis spectabilis, showy orchis
Cimicifuga racemosa, black snakeroot
Actaea alba, white baneberry
Dicentra canadensis, squirrel corn
Impatiens pallida, touch-me-not
Viola canadensis, Canada violet
Aralia racemosa, spikenard
Solidago caesia, wreath goldenrod
Benzoin aestivale, spice bush
Dirca palustris, moosewood

[2] Into Gallatin County, Kentucky (Garman, 16).

All of the trees except sweet buckeye, which extends only throughout the southern half of the State, are generally distributed in Ohio. The plants of the ground layer are generally distributed over the State, with the exception of black snakeroot and Canada violet; these two are less widely distributed in the western half—*i.e.,* oak-forested and forest-grassland transition area—than in the eastern part of the State.

As in the case of the upland forest, the composite range of the tree species coincides with the eastern forested area of the United States. The range of the undergrowth plants of this community is in general the same; their western limit is the eastern boundary of grassland. Most of these plants are inhabitants of mesophytic evergreen forests as well as of mesophytic deciduous forests. A large proportion extend well north of the northern limits of most of the trees of this forest—*i.e.,* into the Northern Mesophytic Evergreen forest. Two species, *Viola canadensis* and *Impatiens pallida,* also occur in the mesophytic forests of the west, though absent from the intervening non-forested area. The climax of the region is characteristically an eastern plant community; the center of dispersal from which its species have come is the Southeastern.

2. *Herbaceous Communities*

a. Ponds and Bordering Swamps.—Ponds and swamps, whether large or small, are accompanied by a vegetation peculiarly their own. Variations from the following list may occur, and many species not here listed may be found in some swamps, but the following may be considered as the most characteristic of our pond and swamp plants:

Typha latifolia, cat-tail
Alisma plantago-aquatica, water plantain
Sagittaria latifolia, arrow head
Leersia oryzoides, rice cut-grass
Spirodela polyrhiza, greater duckweed
Lemna minor, lesser duckweed
Penthorum sedoides, ditch stonecrop
Cicuta maculata, water hemlock
Helenium autumnale, sneezeweed
Acorus calamus, sweet flag
Ludwigia palustris, water purslane

All of these plants are generally distributed in Ohio; most of them are widely distributed over the continent. This is to be expected from the widespread occurrence of the edaphic conditions necessary to these plants. Migration has been greatly facilitated by the nature of the seeds of most of them: very fine, capable of being carried by weak air or water currents, or more effectively still, in small particles of mud transported on the feet of migratory birds (**22**). Swamp plants, pushed south by the glaciers, were probably preserved in the west as well as in the east, wherever local hydrophytic conditions prevailed, and have spread northward again in post-glacial times.

b. Upland Meadows and Forest Openings.—The open meadow association of the uplands, in which grasses are far outweighed in numbers by other plants, and the forest openings of the upland hydrophytic forest possess a flora in common which is entirely distinct from that of any other plant community of the region. These associations are very limited in extent in the western part of this area, and somewhat more extensive eastward, in Clermont County, where the till plains are less dissected.

The most characteristic plants of these associations are:

Rhexia virginica, meadow beauty
Spiraea tomentosa, steeple bush
Gentiana Saponaria, soapwort gentian
Viola lanceolata, lance-leaved violet
Viola sagittata, arrow-leaved violet
Viola cucullata
Habenaria peramoena, purple fringeless orchis
Cardamine bulbosa, spring cress
Polygala sanguinea, milkwort
Aster umbellatus, tall flat-top white aster
Linum striatum, yellow flax
Ludwigia alternifolia, seedbox
Steironema lanceolata, loosestrife
Lobelia cardinalis, cardinal-flower
Eupatorium serotinum, late-flowering thoroughwort
Pentstemon laevigatus, beard-tongue
Scirpus cyperinus
Carex spp.

In addition to these plants, lichens and mosses (*Cladonia pyxidata, C. verticillata, C. mitrula, C. cristatella,*[3] *Catharinea angustata, Ceratodon purpurea, Physcomitrium turbinatum, Climacium* sp.) are very prominent, especially in the earliest stages of the association; pussy willow (*Salix discolor*) frequently appears later; and Sphagnum occurs in certain smaller forest openings, apparently as a relict of earlier, bog conditions.

In contrast to the communities previously discussed, most of the plants of this community are not generally distributed over Ohio. However, they show no particular localization nor limitation to particular phytogeographic areas, but are scattered, singly or in groups about the State, occurring wherever suitable habitats are found.

The general geographic range of the plants of the upland meadow is very similar to that of the climax forest plants, namely, the eastern forest and grassland-forest transition areas. All of these plants are of widespread distribution in the east, and the area of overlap of their ranges is approximately the Ohio river basin—*i.e.,* this area of overlap lies within the Deciduous Forest area. Although a meadow, it is a meadow of an eastern type, without counterpart in the grassland area of the plains. Only two of its species, *Aster umbellatus* and *Steironema lanceolatum,* extend far into the grassland area, and these only in marshy ground. This plant community plainly shows its eastern relationship, and as indicated by present range of most of its species, derivation from the Southeastern Center. However, the earliest phase of this association, and the association just preceding it in the upland succession, namely, the lichen and moss meadow or "tundra," so strongly resemble more northerly associations as to suggest the probability that some of its species, especially those which range little, if any, south of the position of the Southeastern Center, were of boreal origin. In addition to this, the geographic distribution of certain genera here represented (*Salix, Spiraea* and *Gentiana*) and present climatic location of greatest deployment of species of these genera, further indicates boreal origin. It is understood that for this region this did not necessitate southward migration, but rather lagging behind in northward migration accompanying the retreat of the ice. The position of the upland meadow in the upland forest succession further indicates boreal origin. The meadow precedes in succession a forest representing the earliest post-glacial migrations of tree species. The presence of Sphagnum, a constant constituent of bog plant societies, is of special interest here. Although not accompanied by any other typical bog plants, its presence here probably dates back to the early post-glacial migrations of boreal tundra and bog types.

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[3] Lichens determined by Bruce Fink.

c. Prairie Meadow of the Upland.—Somewhat resembling the open meadow association of the upland in appearance, but differing entirely from it in species, is the prairie meadow of the upland. It is much poorer in variety of species than is the open meadow association, and contains a large proportion of grasses, as is shown by the following list:

Andropogon virginicus, beard-grass
Aristida gracilis, triple-awned grass
Aristida oligantha, triple-awned grass
Panicum capillare, witch grass
Oenothera pratensis, sundrops
Pycnanthemum flexuosum, mountain mint
Plantago aristata, large-bracted plantain
Solidago nemoralis, grey goldenrod
Gnaphalium polycephalum, everlasting
Bidens aristosa, tickseed sunflower

Fifty percent of these plants are widely distributed in Ohio; the others are local and scattered. There appears to be no such grouping of these species in other sections of the State as is found here. It is only farther west that a similar grouping may be observed. Two-thirds of these plants range into the Grassland area. All but one species (*Bidens aristosa*) extend far eastward, though in a number of cases the eastern range is rather a peninsular extension of the large western area covered by the species than a widespread range. The area of overlap of all species is farther west than that of the upland meadow species, lying in the eastward peninsular extension of the Grassland–Deciduous-Forest Transition area north of the Ohio river.

Maps showing range of species of the upland meadow community and of the prairie meadow community of the upland would show several marked differences: (1) extensive distribution of most of the upland meadow species in the east; (2) limited distribution of many of the prairie meadow species in the east; (3) a very pronounced western boundary of upland meadow plants coinciding with the western boundary of the Grassland–Deciduous-Forest Transition area and the eastern boundary of the Grassland; (4) no western boundary of prairie meadow plants coinciding with any vegetation area, many of the plants of the community occurring in or even throughout the Grassland area; (5) an extensive area of overlap of ranges of upland meadow species, the area occupying most of the Ohio river basin; (6) a more limited area of overlap of ranges of prairie meadow plants, the area occupying the plateau district north of the Ohio river, a prairie-forest transition area.

At the present time, with the widespread effects of clearing and cultivation, it is difficult to ascertain the exact original extent of prairie patches in the southwestern part of Ohio. At the time that Daniel Drake wrote his history of Cincinnati and the Miami country (**12**) prairies were fairly widespread in the region. From this we learn that the Mad river flowed "through a tract finely diversified with prairie and woodland"; that Montgomery County contained "wide and valuable prairies"; that Green County contained "barrens" produced "by annual burning for a long series of years," but no prairies; that Clinton County had "but little prairie"; that in Clermont County "the soil is generally second rate, and the prevailing timber oak"—no prairie is mentioned and none exists there today; that Kentucky opposite Cincinnati contained no prairies. Prairie land was recognized as next to bottomland in value. From this we may be sure the prairie of that time was not confused with the present upland meadows, which develop on the poorest soil (agriculturally) of the region.

The more widespread existence of prairies in this section in former times establishes a definite connection between our prairie patches and the western grasslands. It explains the evident western relationship of this plant community, and definitely places the Cincinnati Region at the eastern limit of a transition belt

A second type of prairie patch, viz., prairie openings on slopes, is present in the region but is of rare occurrence. It is not treated here, because a detailed investigation is in progress.

d. "Deserts."—By "deserts" is meant a limited and very characteristic plant community of abandoned gravel pits and cuts through gravel deposits on which soil has not yet accumulated. The combination of edaphic factors makes this the most xerophytic community of the region, similar to more extensive areas much farther west.

The plant association is open; the ground is bare, and the plants usually scattered, with a tendency to arrangement in groups of the same species. No species retains its dominance over any considerable part of a single gravel area. Many of the pebbles are heavily coated with a thick crust of lichen, *Verrucaria nigrescens,* which attests to the age and therefore persistence of this primitive gravel habitat and consequently of the plant association dependent upon it. Data as to the rate of growth and ecesis of this lichen (**14**) would place the minimum period for the growth of such a crust at about eight years, if a source of invasion were near at hand. A still longer period would be necessary to account for invasion from a more remote source and ultimate spreading over thousands of square feet of surface.

The plants of the gravel deserts form the most characteristic group of any plant community of the region. All are restricted to gravel soil, but few persisting even as far as the partially closed associations following the gravel desert association. Usually but a few of the following species occur in any one area; the list includes all of the plants of the gravel areas except a few of the most xerophytic of introduced weeds which occasionally appear.

Croton monanthogynus
Croton capitatus
Opuntia Rafinesquii, prickly pear
Opuntia tortispina, prickly pear
Oenothera laciniata, sinuate-leaved evening primrose
Verbena stricta, hoary vervain
Pentstemon hirsutus, beard-tongue
Cenchrus carolinianus, sand bur
Yucca filamentosa
Eupatorium altissimum, tall thoroughwort
Kuhnia eupatorioides
Helianthus hirsutus, rough sunflower
Polanisia graveolens

Only two of these plants, *Pentstemon hirstus* and *Helianthus hirsutus,* are said to be generally distributed in Ohio, which may be interpreted as meaning occurrence wherever there are local edaphically suitable stations. The remainder of the plants, eighty-five percent, are more or less restricted in range, a number occurring in only one or two stations. A map showing the distribution of these plants in Ohio reveals a pronounced grouping along those streams flanked by glacial outwash deposits and along the lake shore—*i.e.,* in areas of sandy and gravelly soil.

The general geographic range of all the plants of this desert community is more pronouncedly southwestern than that of any other community of the region. Cincinnati is at the eastern edge and quite close to the northern edge of the common range of most of the species. Of the thirteen named above, seven reach Florida and only three reach the New England States. Eight of the species are found over a large part or all of the Grassland area, where most of them are recorded as occurring in sandy soil.

From the geographic distribution as compiled from manuals, there would appear to be no common area of overlapping of ranges of all species. This is due to the fact that two of the species, *Yucca filamentosa* and *Opuntia tortispina,* are here far out of their ranges. Both have been brought into the region in cultivation, and have subsequently escaped; now they are thoroughly established as a part of their respective gravel deserts. *Croton monanthogynus* is here at the extreme eastern margin of its range, and is rapidly spreading in suitable habitats within the region, now being a constituent of three gravel desert areas. Its ecesis in one area has taken place within the past two years. *Verbena stricta,* which may be considered the most characteristic of all the plants of gravel soil, because most generally present, is frequently as important, relatively, in its community here as on the western plains. And this is close to the eastern limits of its range.

These gravel areas within the Cincinnati Region are all on stream terraces; most of them border on railroad tracks. This location suggests two of the pathways of migration from western centers as probable inlets, viz., the railway roadbeds and the Great Lakes-stream terrace pathway. The former pathway is indicated by the abundance of some of the species close to railroads, and their almost complete absence elsewhere, the latter by the distribution in Ohio and greater frequency of some along the lake shore.

Geographic range points strongly to a southwestern derivation for most of the plants of the community. Ecological relations of habitat with pathways of migration further strengthen the probability of southwestern origin. The absence of variation and the remarkable uniformity of most of these plants in this region indicate remoteness from the center of dispersal. Relationship of species, location of greatest numbers of related species and of greatest differentiation of type, all indicate southwestern origin for the gravel desert community.

C. Miscellaneous Plant Colonies and Individuals Not Assignable to Distinct Communities

1. A Relict Colony.—Plants of the Heath family, except the saprophytic Indian pipe, have been quite generally believed to be entirely absent from the calcareous region of southwestern Ohio. For this reason, the occurrence of two members of the family, *Pyrola elliptica* (shin leaf) and *Chimaphila maculata* (pipsissewa or spotted wintergreen), in considerable numbers in one small area, is of unusual interest. With these two species are two other plants not found elsewhere in our region—*Hieracium paniculatum* (hawkweed) and *Chamaelirium luteum* (blazing star). Two of the mosses found in company with these plants—*Bartramia pomiformis* and *Leucobryum glaucum*—are almost entirely absent from other parts of the region.

This remarkable colony of plants grows in a rather deep east-west ravine cutting the till-covered upland. The ravine, once much deeper than at present, is partly filled with black mucky soil and sand. The lower slopes of the ravine, next the flat-bottomed fill, are also sandy. The north slope (northward facing) is extremely steep and supports a mesophytic forest. The soil is yellow, but very sandy. The slope exposure and density of the surrounding forest is such that no hot sun ever shines upon this slope. Here the patch of *Pyrola* grows, set in deep cushions of mosses (*Bartramia, Catharinea* or *Polytrichum*).

The south slope of the ravine is gentle and cut by many entering ravines into low ridges. Here, in the deep, black, sandy soil, and very little above the level of the valley fill, is a scattered band of pipsissewa. The hawkweed and blazing star occupy similar positions, but slightly higher on the slopes. On some of these slopes, in very dry sandy soil, are patches of *Leucobryum.*

All of the plants here mentioned are common in coniferous woodlands east and north of our region. All are far west or southwest of their recorded ranges in Ohio (25, 18). Three, *Pyrola elliptica, Chimaphila maculata* and *Hieracium paniculatum,* are Alleghanian plants, whose presence here can not be explained by recent migrations. The presence or rather persistence of this colony is to be sought in the glacial or early post-glacial history of the ravine in which it is found.

The ravine appears to have been dammed during glacial or early post-glacial times about a mile from its source. This has resulted in rather extensive filling, apparently first lacustrine, later swamp. A black mucky soil now forms the surface of the fill. The slopes of the ravine, instead of loess or till soil, as is usual in upland ravines, are sandy, indicating excessive drainage during the glacial period. The present swamp and all entering ravines are spring fed. The supply of water is abundant and constant. Thus the soil water is at a temperature lower than is general. This would tend to favor the persistence of any boreal species which might have gained a foothold along the lake or bog margin during the earlier post-glacial migrations.

2. PLANT COMMUNITIES OF CONGLOMERATE ROCK OUTCROPS.—The vegetation of conglomerate rocks (7), while ecologically interesting because of the ideal succession displayed, and because of its isolation, presents little of phytogeographic interest. Its most characteristic vascular plants, *Camptosorus rhizophyllus, Cystopteris bulbifera, Pellaea atropurpurea, Woodsia obtusa, Mitella diphylla* and *Aquilegia canadensis,* have a wide range in eastern United States and occur wherever suitable habitats are found.

3. SOUTHERN PLANTS.—In addition to those plants that have already been mentioned in connection with distinct communities, as here reaching their northern limit, a few other species are worthy of note. *Quercus texana* (southern red oak), *Dentaria multifida* (toothwort) and *Spermacoce glabra* (buttonweed) are known in Ohio from Hamilton County only. *Dentaria multifida,* an inhabitant of a mesophytic woods, is here far north of its usual range (5). *Quercus texana,* occasional on gravelly till soils of Mill Creek valley, is at the northeastward extension of its range in the Ohio valley. It is recorded from the southwestern counties of Indiana and from several counties of Kentucky. *Spermacoce glabra* and *Leptochloa filiformis* are found on rocky banks of the Ohio river, the first on both the Ohio and Kentucky shores within the Cincinnati Region and west of the Cincinnati Region in the southern counties of Indiana; the second on the Kentucky shore of the Ohio in the Cincinnati Region. Present records indicate that

they do not extend farther up the river. *Diodia teres* (buttonweed), recorded from Lake and Hamilton Counties, Ohio, is an occasional and locally abundant inhabitant of barren fields in the Cincinnati Region both in Hamilton County, Ohio, and Kenton County, Kentucky. It has a decidedly southern range in Indiana also, and is a far southern species, extending northward on the coastal plain and in the Mississippi valley. *Desmanthus illinoensis*, a southern and western plant of prairies and alluvial soil, is not uncommon in our region along stream banks.

4. Western or Southwestern Plants.—While western plants form a prominent part of three of our plant communities—prairie meadow of the upland, prairie openings on slopes, and "deserts"—they are by no means limited to these communities, though nowhere else characteristic. The plants here considered may be grouped into: (*a*) those found only along railroad tracks and not yet established elsewhere; (*b*) plants of barren (graded or washed) fields; (*c*) plants of gravel terraces.

(*a*) *Plants Found Along Railroad Tracks.*—While some of the plants first recorded from railroad tracks have become established in gravel desert areas, others have not yet made the last step in their migration and invaded some community. *Festuca octoflora* (fescue grass), *Cleome serrulata* (Rocky Mountain bee-flower), *Strophostyles pauciflora* (wild bean) and *Cycloloma atriplicifolia* (winged pigweed) are western plants just entering our region.

(*b*) *Plants of Barren Fields.*—In small local areas from which the top soil has been removed by grading, or by excessive wash, are found a few plants uncommon in this region. *Euphorbia marginata* (snow-on-the-mountain), *Grindelia squarrosa* (gum-plant), *Hypericum Drummondii, Helenium nudiflorum* (sneezeweed) and *Helianthus Maximiliana* are of local occurrence, the first two in large patches. Snow-on-the-mountain is probably an escape from cultivation, locally established in considerable abundance in dry rocky fields. *Grindelia squarrosa,* at least in one instance, was probably introduced with grass seed. It has persisted in one Kentucky location in the region, but shows no evidence of further spreading. The other three plants, *Hypericum Drummondii,*[4] *Helenium nudiflorum*[4] and *Helianthus Maximiliana,* are less abundant than are the two first mentioned.

(*c*) *Plants of Gravel Terraces.*—In the herbaceous and forest associations of gravel terraces and river bluffs there are a few distinctive plants not appearing in associations of corresponding successions on other soils. *Hypericum cistifolium, Verbena canadensis, Pentstemon tubiflorus* and *Pentstemon grandiflorus* on the terraces, and *Rhus canadensis* on the bluffs, are strictly limited to stream terraces—*i.e.,* to gravelly soil—in the Cincinnati Region. Three of these—*Hypericum cistifolium, Pentstemon tubiflorus* and

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[4] Listed by Kearney (21) among the Lower Austral plants of the southern Appalachians.

Pentstemon grandiflorus—are at the eastern limits of their ranges. *Verbena canadensis* has a wider range and is found far west as well as east. *Rhus canadensis* is a frequent inhabitant of dry bluffs and of sand dunes, and, if its varieties *illinoensis* and *trilobata* be included, has a very extensive range.

IV. SUMMARY AND CONCLUSIONS

The present flora of the Cincinnati Region is a result of the mingling of plants derived from various centers of dispersal. The influence of the Southeastern Center is most pronounced. The vegetation from this center gives the characteristic physiognomy to most of the plant communities. The western centers (Desert and Prairie) have been second in importance in determining the composition of the flora. Migration from these centers has determined in large part the flora of three of the plant communities. This is most strikingly exhibited in the "desert" community. Boreal forms play a less prominent part in the region, and are found as a part of two communities, the upland forest and the upland meadow. These associations are undoubtedly the oldest, successionally, in the region; a part of their flora has persisted from early post-glacial times.

The various elements from these different centers have been derived by migrations—either early post-glacial or recent. Seven entering paths of migration are distinguished. Two of these are from the Southeast—one may also serve to permit the entrance of species from the South or from tropical regions. Two modes of entrance of Boreal forms into our flora are pointed out—one migratory and of doubtful value in the present instance, the other passive, a mere lagging behind in migration. Plants from the western centers seem to have invaded the region by means of three pathways. Two of these give certain evidence of their value, a third is more doubtful.

The plants of the Cincinnati Region are grouped in distinct communities which exhibit marked communal relationships with the south, the west, or the north. The habitat of the communities is in all cases closely related ecologically to the migration pathway which is believed to have been most important in determining the floristics of the community.

A study of the floristics of the various communities points to the fact that the Cincinnati Region lies in a transition belt. Here is found the northern or northeastern limit of a number of southern plants. Here should be placed the eastern margin of the transition belt between the prairie region to the west and the deciduous forest area of the east.

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